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THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

ACCEPTANCE STANDARDS FOR NONDESTRUCTIVE TEST NOT REQUIRED BY CLASSIFICATION

(PHASE II)

U.S. DEPARTMENT OF TRANSPORTATION
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IN COOPERATION WITH
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AMERICAN BUREAU OF SHIPPING

NONDESTRUCTIVE TESTS

NOT REQUIRED BY CLASSIFICATION

(PHASE II)

JUNE 1985

AMERICAN BUREAU OF SHIPPING

65 BROADWAY

NEW YORK, N.Y. 10006

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FOREWORD

The purpose of this report is to present the results of Phase II of one of the projects initiated by the members of the Ship Production Committee of the Society of Naval Architects and Marine Engineers and financed largely by government funds through a cost-sharing contract between the U.S. Maritime Administration and Newport News Shipbuilding. The objective of the evaluation was to provide information relative to those hull welds with satisfactory service experience that would not normally be required to be nondestructively inspected for classification. The project involved evaluation of the internal soundness of existing ship hull welds by ultrasonic testing. Phase I examinations were confined to flat position submerged arc welds (SAW); Phase II examinations reported herein involved 25% flat position SAW and 75% vertical position shielded metal arc welds (SMAW).

Special acknowledgment is made to the members of Welding Panel SP-7 of the SNAME Ship Production Committee who served as technical advisors in the preparation of inquiries and evaluation of subcontract proposals; to Mr. B.C. Howser, Newport News Shipbuilding, SP-7 Panel Chairman and to Mr. M.I. Tanner, Newport News Shipbuilding, SP-7 Program Manager. Acknowledgement is also extended to the Newport News Shipbuilding Nondestructive Test Department whose personnel conducted the Ultrasonic Testing and to Mr. Kenneth W. Fritsche, James River Reserve Fleet Superintendent, for his cooperation and assistance in providing the specially designed and constructed boats for performing the water borne inspections.

The program was carried out by the American Bureau of Shipping under the direction of Mr. I.L. Stern; Mr. M. Wheatcroft was the Project Manager; Dr. D.Y. Ku, and Mr. D. Cantore served as Project Engineers.

ABSTRACT

Current ABS requirements relative to nondestructive test and acceptance standards for radiographic and ultrasonic inspection are mainly intended for intersecting full penetration welds within the midship 0.6L, especially those in the sheer strake, bilge strake, deck stringer, keel plate, and butts in and about hatch corners in main deck and in the vicinity of breaks in the superstructure. At times, a shipyard may perform up to 100% nondestructive examination, at other locations, for the purpose of internal quality control or to satisfy a contractual agreement. Acceptance standards for locations that are beyond Classification Society requirements are not defined.

The objective of Phase II was to determine the quality of manual welds made in the vertical position and additional automatic submerged arc welds made in the flat position, in ships that had proven satisfactory in service, and compare these results with those obtained in Phase I (automatic submerged arc welds made in the flat position). To accomplish this, ultrasonic examinations were made of side shell weld intersections in twenty ships built during the 1943-1976 period.

INTRODUCTION

The purpose of the project was to evaluate the internal quality of those welds, in ABS classed ships, which are not normally examined by ultrasonics or radiography during the course of construction. The data would provide information relative to the quality of welds which had exhibited prolonged satisfactory service and could offer guidance to those concerned with evaluation of UT results of such welds.

For ships built to ABS requirements, nondestructive inspection of hull welds by radiography or ultrasonics is governed by ABS Rules for “Nondestructive Inspection of Hull Welds" or equivalents. The Rules provide for a representative number of checkpoints as determined from the following equation:

n = L (B+ D)/500 inch units n = L (B+D)/46.5 metric units

n = Minimum number of check points

L = Length of the vessel in m or ft. between perpendiculars

B = Greatest molded breadth in m or ft.

D = Molded depth at the side in m or ft. measured at L/2

The locations of these checkpoints are indicated in Enclosure 1; the applicable standards and acceptance criteria are indicated in Enclosure 2 and 3 respectively.

Sampling in accordance with the check point formula is useful as a quality control measure, in that the quality level of the inspected areas is considered to be representative of the overall weld quality. The use of RT or UT in accordance with the Rules provides a measure of general shipyard quality control. Acceptance levels for allowable sizes of discontinuities specified in the NDT Rules are not based on fracture mechanics analyses since the variety and complexity of factors involved could make such analyses of questionable validity. The acceptance/reject levels of the Rules are based on experience and indicate the level of quality that should be reasonably expected with normal shipyard procedures and practices; the reject level at an isolated location does not necessarily indicate that the discontinuity represents a threat to the safety of the vessel.

Phase I of the investigation involved the ultrasonic examination of deck welds made by the automatic submerged arc process (SAW). The results of the ultrasonic examination were evaluated using both the existing ABS Rule standards and the guideline criteria of Table III.

The analysis of the results of Phase I showed that the overall quality of ship welds examined was high and that the use of “Guidelines” in lieu of “ABS Rules” to evaluate welds between intersections only resulted in a relatively small reduction of nonconforming welds for ships where workmanship was generally of good quality. In Phase II additional ultrasonic data was to be obtained from flat SAW and vertical SMAW welds located on the side shell of the ships, with a view toward providing data comparable to that obtained in Phase I . As with Phase I , a MARAD ready reserve fleet located on the James River in Newport News, Virginia was made available for the subject study.

APPROACH

The approach was to use ultrasonic inspection to determine the internal quality of welds that would normally not be examined by UT or RT during construction. By sampling a sufficient number of ships and types of welds, an assessment could be made of the typical weld quality that had proven satisfactory in service. This assessment was made on the basis of the following two criteria (see Table III):

a) Present ABS Rules: The acceptance criteria which are indicated in Table III were used. As previously noted, the midship welds between intersections would not generally be subjected to ultrasonic examination.

b) ABS Guidelines: These guidelines, which are indicated in Table III, have been used by various parties concerned in specific cases where the ship owner or ship designer and the shipyard did not have complete agreement as to an appropriate weld acceptance criteria (i.e. for locations where ABS inspection requirements did not apply).

Shipyard personnel and standard ABS procedures were used for the inspection. The inspection was carried out with a 3/4" x 1", 2.25MHz, 60° angle shear wave transducer. The surface conditions, calibration, and couplant used met the requirements of SOP 038-7.245 Rev. C Class A, "Ultrasonic Inspection Of Butt Welds", which is basically equivalent to NAVSEA 0900-006-3010 and ABS NDT Rules.

Indications greater than or equal to the DRL (Disregard Level, 40% of screen height) as defined in Enclosure 4, were to be reported and their length determined.

A total of 20 ships were examined, namely;

14 General Cargo

3 Container

1 Combination

1 Ro Ro

1 Tanker

Details as to type of ship, dimensions and year built are shown in Table I.

These ships were in the 400 to 500 ft. length range (except for one of 734 ft.). They were built between 1943 and 1976 with the majority built during 1944 - 1945 (see Table I for specific details). A total of 488 inspection locations (versus 279 in Phase I) in the 20 ships (versus 18 in Phase I) were examined; each inspection location consisted of a 24 in. long checkpoint; 70% of the checkpoints were located in the 0.6L midship section, and 30% located outside the midship (0.6L) section. An average of 25 checkpoints per ship were examined; total length of weld examined was 11,712 inches. All welds were in the side shell, close to the water line.

RESULTS

Results of the inspection are shown in Tables I and II. Recordable indications are indications on the CRT screen whose peak is above 40% of the screen height (DRL). Of the 20 ships subjected to UT inspection, only two had checkpoints with recordable indications (above 40% DRL). One ship had a total of 3.75" of recordable indications in four separate areas (out of 26) with none of sufficient length to be considered outside the ABS Rule acceptance criteria; the other ship had a total of 6.375" of recordable indications in four separate areas (out of 27); only one 3" length (of the total of 11,712 inches examined) was outside the ABS Class B acceptance criteria and one 1-1/4" length was outside the ABS Class A criteria. All of the recordable indications were from vertical position SMAW field welds located in the midship 0.6L. For the remaining 18 ships, all of the inspected locations were found free of recordable indications (greater than or equal to 40% DRL).

DISCUSSION

In general, the random spot examinations appeared to be a reasonable approach to the overall assessment of hull weld quality. In addition, it appears that the results obtained support the tentative conclusions of the previous Phase I report, i.e. any relaxation of the current ABS NDT acceptance standards would not have a significant effect on the number of required repairs when weld qualities were those reasonably expected from a shipyard.

CONCLUSION

The analysis of the results are in general agreement with the conclusions reached in Phase I:

Overall quality of ship welds examined was high.
Use of the "ABS Guidelines" in lieu of the "ABS Rules" to evaluate the welds resulted in no change in the acceptance / rejection status of the recordable indications.

FUTURE WORK

As requested by the SNAME SP-7 panel, a proposal will be submitted to conduct a study similar to that described herein which will be directed to U.S. Navy ships.

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TABLE I SHIPS SUBJECTED TO ULTRASONIC EXAMINATION

SHIP NO.	TYPE	DIMENSIONS	YEAR BUILT	RECORDABLE INDICATIONS YES / NO
MV19	Comb.	560’ X 90’ X 59’	1969	Yes
MV20	Gen. Cargo	496.67’ X 71.5’ X 43.5’	1945	Yes
MV21	Ro Ro	733.75’ X 92’ X 42.14’	1976	No
MV22	Gen. Cargo	541’ X 75’ X 42.83’	1963	No
MV23	Gen. Cargo	436.5’ X 62’ X 38’	1945	No
MV24	Gen. Cargo	436.5’ X 62’ X 38’	1945	No
MV25	Gen. Cargo	436.5’ X 62’ X 38’	1945	**No**
MV26	Gen. Cargo	436.5’ X 62’ X 38’	1945	**No**
MV27	Gen. Cargo	528.5’ X 76’ X 35.5’	1952	No
MV28	Gen. Cargo	508.15’ X 75’ X 42.81’	1965	**No**
MV29	Gen. Cargo	436.5’ X 62’ X 38’	1944	No
MV30	Gen. Cargo	436.5’ X 62’ X 38’	1945	**No**
MV31	Gen. Cargo	436.5’ X 62’ X 38’	1945	No
MV32	Tanker	503’ X 68’ X 39.25’	1943	**No**
MV33	Gen. Cargo	436.5’ X 62’ X 38’	1945	No
MV34	Container	581.83’ X 78’ X 54.5’	1969	**No**
MV35	Container	581.83’ X 78’ X 54.5’	1969	**No**
MV36	Container	581.83’ X 78’ X 54.5’	1973	**N**o
MV37	Gen. Cargo	436.5’ X 62’ X 38’	1945	No
MV38	Gen. Cargo	539.5’ X 68’ X 39.25’	1944	No

TABLE II

SHIPS WITH RECORDABLE INDICATIONS

Ship	No. of Checkpoints	Total Length inspected (inch)	No. of Checkpoints with recordable indications	Plate Thickness (inch)	Screen Height %	Length of indicator (inch)	Acceptance criteria met	Midship Location Yes/No
MV19	26	624	4	0.78	80	1	A	NO
				0.80	70	7/8	A	YES
				0.80	100 +	1 1/8	A	YES
				0.75	80	3/4	A	YES
						3 3/4		
MV20	27	648	4	0.73	70	1 1/4	B**	YES
				0.80	60	1	A	NO
				0.73	60	1 1/8	A	YES
				0.77	60	3	NA*	YES
						6 3/8		

*Did not meet class B acceptance criteria

**Did not meet Class A acceptance criteria

TABLE III

NONDESTRUCTIVE TESTING ACCEPTANCE CRITERIA (1) (2)

	AT INTERSECTIONS WITHIN MIDSHIP 0.6L	AT INTERSECTIONS OUTSIDE MIDSHIP	BETWEEN INTERSECTIONS WITHIN MIDSHIP 0.6L BUTTS	BETWEEN INTERSECTIONS WITHIN MIDSHIP 0.6L SEAMS	BETWEEN INTERSECTIONS OUTSIDE MIDSHIP BUTTS	BETWEEN INTERSECTIONS OUTSIDE MIDSHIP SEAMS
ABS Rules	A*	B*	--	--	--	--
ABS GUIDELINES	A*	B*	2A	2B	2B	2B

* As defined in Enclosure 3

NOTES:

(1) In general, for relatively unimportant areas for which less than a twice Class B criteria could be tolerated, the use of RT or UT is not considered applicable.

(2) Applied to surface vessels 150m (500 ft.) and over.

ENCLOSURE 1

EXCERPT FROM ABS 1975 "RULES FOR NONDESTRUCTIVE INSPECTION OF HULL WELDS"

2.4 Location of Ultrasonic Inspection

2.4.1 Critical Locations

a Surface Vessels Ultrasonic inspection within the midship 0.6L is to be carried out mainly in locations such as intersections of butts and seams in the sheer strakes, bilge strakes, deck stringer and keel plates, and butts in and about hatch corners in main decks and in the vicinity of breaks in the superstructure. Particular attention is to be directed to field erection joints and any suspected problem areas. Where inspection is to be carried out at weld intersections a minimum of 250mm (10 in.) of weld, measured from the intersection in each direction transverse to the axis of the vessel butt weld is to be inspected. In addition, a minimum of 125mm (5 in.) of weld, measured from the intersection in each direction longitudinal to the axis of the vessel seam weld, is to be inspected.

b Other Marine Structures Ultrasonic inspection is to be carried out mainly in areas which may be subjected to high stress. In the case of column support structures, particular attention is to be given to the intersection of longitudinal seam welds with circumferential butt welds.

2.4.2 Other Locations

a Surface Vessels Ultrasonic inspection outside the midship 0.6L is to be carried out at random in important locations such as those specified in 2.4. la above at the discretion of the Surveyor.

b Other Marine Structures Ultrasonic inspection in other than the critical locations indicated in 2.4.1b is to be made at the discretion of the Surveyor.

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ENCLOSURE 2

EXCERPT FROM ABS 1975 "RULES FOR NONDESTRUCTIVE INSPECTION OF HULL WELDS"

2.5 Applicable Standards

2.5.1 Class A

a Surface Vessels Ultrasonic inspection of full penetration welds for all surf ace vessels 150m (500 ft.) and over, in the critical locations indicated in 2.4. la, is to meet the requirements of Class A. Class A may also be specified and applied to surface vessels less than 150m (500 ft.) when special hull material or hull design justifies this severity level.

b Other Marine Structures Ultrasonic inspecion of full penetration welds in critical locations such as those indicated in 2.4.lb is to meet the requirement of Class A.

c Liquefied Natural Gas (LNG) and Liquefied Petroleum Gas (LPG) Carriers Ultrasonic inspection of full penetration welds in way of integral or independent tanks of all vessels intended to carry LNG or LPG cargo is to meet the requirements of Class A.

2.5.2 Class B

a Surface Vessels Ultrasonic inspection of hull penetration welds for surface vessels under 150m (500 ft.) and for the other locations indicated in 2.4.2a, regardless of the size of the vessels, is to meet the requirements of Class B provided that Class A has not been specified in accordance with the special conditions noted in 2.5.la.

b Other Marine Structures Ultrasonic inspection of full penetration welds for the other locations indicated in 2.4.2b is to meet the requirements of Class B.

ENCLOSURE 3

EXCERPT FROM ABS 1975''RULES FOR NONDESTRUCTIVE INSPECTION OF WELDS"

2.6 Acceptance Criteria

2.6.1 Class A

a Indications Greater than the ARL Welds in which the ultrasonic indications produce a signal which exceeds the ARL (as established in 2.2.7) and has a length greater than 12.5mm (0.50 in.) are unacceptable. Indications less than 4.8mm (0.187 in.) in length may be disregarded. Indications 4.8mm (0.187 in.) to 125mm (0.50 in.) in length are to be evaluated in accordance with 2.6.lb.

b Indications Greater than the DRL Welds in which ultrasonic indications produce signals which are greater than the DRL are unacceptable if the signals are indicative of discontinuities greater in length than those shown in the respective curves of Figures 2.5 and 2.6 for single or total accumulated length. Indications less than 4.8mm (0.187 in.) in length may be disregarded.

c Indications Less than the DRL Ultrasonic signals which are less than the DRL are to be disregarded.

2.6.2 Class B

a Indications Greater than the ARL Welds in which the ultrasonic indications produce a signal which exceeds the ARL (as established in 2.2.7) and has a length greater than 12.5mm (0.50 in.) are unacceptable. Indications less than 4.8mm (0.187 in.) in length may be disregarded. Indications 4.8mm (0.187 in.) to 125mm (0.50 in.) in length are to be evaluated in accordance with 2.6.2b.

b Indications Greater than the DRL Welds in which ultrasonic indications produce signals which are greater than the DRL are unacceptable if the signals are indicative of discontinuities greater in length than those shown in the respective curves of Figures 2.5 and 2.6 for single or total accumulated length. Indications less than 4.8mm (0.187 in.) in length may be disregarded.

c Indications Less than the DRL Ultrasonic signals which are less than the DRL are to be disregarded.

ENCLOSURE 4

EXCERPT FROM ABS 1975''RULES FOR NONDESTRUCTIVE INSPECTION OF HULL WELDS"

2.2.8 Weld Inspection

a Longitudinal Discontinuities In order to detect longitudinal discontinuities which may be present in welds or heat affected zones, the transducer is to be moved in a selected overlapping pattern similar to that shown in Figure 2.3. Simultaneously while moving along the path of inspection, the transducer is to be oscillated through a small angle. The length of weld to be inspected is to be scanned with the transducer directed in two distinct paths, either or both sides of the weld from the same surface, or on opposite surfaces from the same side of the welds.

b Transverse Discontinuities In order to detect transverse discontinuities which may be present in welds, the transducer is to be angled about 15 degrees from the weld axis and moved parallel to the welds length as shown in Figure 2.3. The scan is then to be repeated on the same surface (if accessible) on the other side of the weld. Both scans are to be made with the transducer moved in the same direction. Alternatively, where inspection is not accessible from the same surface on both sides of a weld, a second scan is to be made on the opposite surface from either side of the weld. For welds in which the surfaces have been ground, the transducer is placed on the weld surface and moved along the weld axis with the sound beam directed parallel to the weld.

2.2.9 Discontinuity Length Determination

When discontinuities are indicated the sound beam is to be directed so as to maximize the signal amplitude. The transducer is then moved parallel to the discontinuity and away from the position of maximum signal amplitude until the indication drops toward the base line. Using the center line of the wedge of the transducer as an index, the extremity points of the discontinuities are determined as indicated in a and b.

a Indications Greater than ARL For indications with peak amplitudes greater than the ARL (over 80% of full screen height), the extremity points of the discontinuity are defined as the points at which the signal drops to 40% of full screen height.

b Indications Greater than DRL For indications with peak amplitudes of 90% or less of full screen height, the extremity points of the discontinuity are defined as the points where the signal amplitude either remains below the DRL (40% of full screen height) for a distance equal to 1/2 the major dimension of the transducer or drops to 1/2 the peak amplitude, whichever occurs first (i.e. the points which define the shortest discontinuity length).

2.2.10 Ultrasonic Inspection Reports

Ultrasonic inspection reports are to be filed for record and are to include the hull number, exact location and length of the welds inspected, equipment used, instrument identity, transducer type, size, frequency, angle, base metal type and thickness, weld process, any unusual condition of weld bead (ground undercut, etc.) weld joint design, the specific class to which examination is being carried out and all reflections which are interpreted as failing to meet the specified requirements (as defined in 2.6), dates of inspection and signature of ultrasonic operator, (A typical report form), shown in Figure 2.4, is considered acceptable. The method for review and evaluation of ultrasonic test reports is to assure adequate quality control and is to be to the satisfaction of the Surveyor.